CAN TRAUMA SCORING SYSTEMS PREDICT THE NURSING COSTS OF TRAUMA CARE?

by

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ABSTRACT

Scoring systems are presently employed to triage trauma patients to the appropriate facilities for care. Trauma patients need highly technical nursing skills, which are costly.

Five scoring systems, the Glasgow Coma Score (GCS), Trauma Score (TS), Revised Trauma Score (RTS), CRAMS Scale, and Injury Severity Scale (ISS) were compared with an automated nursing acuity system at a Level I trauma center to determine if the trauma scores could also be used to predict the nursing costs of 448 trauma care patients who were aeromedically transported.

One-way analysis of variance was performed with a resultant significant $\underline{F}$ test ($\underline{p} \leq 0.000$) for each of the five scoring systems. Bartlett and Cochran's tests checked homogeneity of variance. Student-Newman-Keuls posthoc tests showed additional differences within each scoring system. The GCS, TS, TS, CRAMS, and ISS can all predict nursing costs for trauma care.

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CHAPTER I

INTRODUCTION

Trauma is defined as accidental or intentional injuries. The Center for Disease Control (1982) and the Committee on Trauma Research (1985) state costs for trauma care are higher than for any other major health problem. Kenner, Guzzetta, and Dossey (1985) suggest that more than $80 billion a year is spent for the care of trauma victims.

As technology has improved and public demand for care increased, health care costs have escalated. Because trauma patients require more time in an intensive care unit (ICU) and a longer length of stay in the hospital than other patients (Kenner et al., 1985), care of the trauma patient is associated with high nursing care costs (Mowry & Korpman, 1985). Paradoxically, in the face of a demand for more technological nursing skills to provide the necessary care for severely injured patients, the United States is facing a nursing shortage and a push to reduce costs (King, 1989). There is a growing concern regarding how these demands will be met.

Trauma triage scoring systems are presently employed to measure the severity of injuries in order to direct trauma victims to appropriate facilities. The purpose of this study was to determine if currently used injury severity scores can be used to predict the nursing care costs for traumatized patients.

Historical Background

Wars and skirmishes have always left wounded victims. Farm accidents and industrial accidents have produced other types of injuries. Additionally, humans continue to develop equipment and activities -- machinery, trains, planes, automobiles, motorcycles, all-terrain-vehicles, sports, and the use of alcohol (Reilly, Kelley & Faillace, 1986) -- that have the potential to generate trauma.

Most of the advances in trauma care have occurred as a result of experiences in the military. Hand and horse drawn ambulances began transporting casualties from battlefields before the advent of motor transportation. Motor driven vehicles transported victims of World War I in crude vans. During World War II, simple biplanes were included in the methods of transferring the wounded. This allowed air transport to hospital bases, where the soldiers could receive faster and more appropriate care, resulting in fewer deaths. The advent of helicopters in the Korean War eliminated the need for traditional runways and patients could be airlifted directly from the battle zone. Helicopter transport resulted in an even greater reduction in morbidity and mortality. In addition to improved transportation systems, specially trained personnel, such as paramedics, trauma nurses, and physician specialists, further reduced mortality rates from 8% in World War I to less than 2% in the Vietnam War (Boyd, Edlich & Micik, 1983).

Defining Trauma Care Systems

A trauma victim's outcome following an accident depends on the severity of the injury, the speed with which treatment is begun, and the expertise of the health care professionals (Trunkey, 1982). Prior to the 1960s, transportation and care of civilian trauma victims were poorly organized, with scant attention paid to the need for specialized care. In 1966, the publication of the National Academy of Science/National Research Council White Paper entitled "Accidental Death and Disability: The Neglected Disease of Modern Society," drew attention to the need for trauma care. The Highway Safety Act of 1966 was enacted, mandating that each state provide emergency medical services. In 1971, the Emergency Medical Services System Act, with revisions in 1973 and again in 1976 provided more specific guidelines to reduce morbidity and mortality (Boyd, 1982, 1983; Boyd & Cowley, 1983).

Emergency Medical Systems (EMS) were developed to improve the quality of care. After being summoned to the scene, first responders, Emergency Medical Technicians

(EMTs) and paramedics, provide initial care. The rapid stabilization and transfer of trauma victims by EMS personnel decreases the time before specialized interventions can be initiated.

In order to provide trauma care, the American College of Surgeons (1979, 1983) established guidelines for Level I, II, and III trauma centers. A Level III or local hospital provides immediate assessment and stabilization before transferring a trauma patient to a Level I or II hospital. A Level II hospital provides trauma service that includes a trauma surgeon who would be in the emergency department by the time the trauma patient arrives.

A level I regional trauma facility provides complete in-hospital care by specialists. Among an extensive list of requirements, a level I facility must have an emergency room physician proficient in critical care delivery present 24 hours a day. It must have general and neurological surgical services and personnel with computerized tomography available 24 hours a day. It must have a trauma research/teaching program and ICUs with a nurse-patient maximum ratio of 1:2 each shift.

Defining Injury Severity

To facilitate rapid assessment of injury severity and to assure treatment commensurate with injuries, a variety of triage systems were developed to determine the type of hospital facility most appropriate for a particular trauma patient. Inappropriately triaged trauma victims could be transported to a primary care facility that would not have the resources to provide the care necessary for a severely wounded patient. Conversely, patients with only minor injuries inappropriately triaged could be transported to a highly developed tertiary center.

Trauma triage scoring systems vary from physiologic scales to consolidation of anatomic, clinical, and physiologic criteria. The Glasgow Coma Score (Teasdale & Jennett, 1974), the Trauma Score (Champion, Sacco, Carnazzo, Copes & Fouty, 1981), the Revised Trauma Score (Champion et al., 1989), the CRAMS Scale (Gormican, 1982), and the Injury Severity Score (Baker & O'Neill, 1976; Baker, O'Neill, Geddon & Long, 1974) are among injury scores currently used.

Current Costing Practices

In an effort to curtail accelerating costs, Diagnostic Related Groups (DRGs) were implemented by the federal government under the Social Security Amendments of 1983. Use of the DRG system was predicated on the assumption that there was a random distribution of patients to all hospitals; therefore, reimbursement based on average costs of care would benefit all hospitals equally. Another assumption was that DRGs would reflect the actual costs incurred during a hospital stay (Federal Register, 1983).

Because trauma patients have longer lengths of stay and longer ICU lengths of stay, they do not meet the normal DRG assumptions and their care requires greater costs (Cone & Eisner, 1989). Thomas et al. (1988) showed a major financial loss would result to institutions under the Medicare DRG payment system for trauma patients, with Medicare paying only 16% of the costs. However, in the study by Thomas et al., since Medicare patients amounted to only 4% of the trauma patients, losses under the Medicare reimbursement system were minimal. However, the study did show that if the Medicare prospective reimbursement system was implemented by third-party payers, major financial losses would be incurred by trauma centers.

Under a DRG prospective payment for all patients, Schwab et al. (1988) found that a trauma center would lose $1.86 million in 1 year. Similarly, DeMaria, Merriam, Casanova, Gann, and Kenny (1988) found hospital costs surpassed projected DRG remuneration by $2.55 million a year for trauma patients. DeMaria et al. stated older patients' costs were higher than those of other populations. Roye, Dunn, and Moody (1988) found the average hospital charges per cervical spinal cord injury were $50,370, with DRG reimbursement being only $12,285. Bennett, Jacobs, and Schwartz (1989) found 49% of the total charges, or $6.9 million, were nonreimbursable by DRG for traumatic brain injuries.

The DRG prospective payment system has also raised new concerns for nursing administrators. Nursing represents a significant proportion of the hospital cost per patient (Mowry & Korpman, 1987). Wilson, Prescott, and Aleksandrowicz (1988) claim studies of nursing costs show a wide variation, from $706.00 to $1,778.00, for patients within the same DRG category. The more ill or injured the patient, the greater the nursing costs, which may vary as much as 500% for the same DRG categories during the patient's stay (Mowry & Korpman, 1987).

Implications for Nursing

With increased trauma patient acuity, the need for highly technical nursing skills, and an all-time high for nursing shortages (King 1989), there is a growing concern regarding how nursing will meet these demands. A 1988 study showed there were 13.8% vacant full-time and part-time critical care nursing positions throughout the United States (Searle, 1988). The American Hospital Association's 1986 annual survey of all hospitals showed an increase in critical care beds by 43% since 1979. It also showed 87% of the responding hospitals needed 60 to 90 days to recruit ICU staff nurses (Curran, Minnick & Moss, 1987).

Health care costs have increased dramatically as technology developed and the demand for care has grown. Trauma centers were established to decrease morbidity and mortality among trauma patients. Trauma costs exceed those for other types of diagnoses. ICUs require more nurses with increased technical and assessment skills to provide care for trauma patients at a time when nursing shortages are acute. The DRG prospective payment system often fails to provide adequate reimbursement of the true costs for care provided to the seriously injured.

If trauma scoring systems can be used to predict the costs of trauma nursing, costs will have been identified for one population. As answers are provided in one area, it is hoped these data will serve as a catalyst for cost studies in other areas. Identifying nursing costs will help nursing administrators be more effective in decision-making to improve internal operating efficiency. The results will provide more concrete financial information for use in determining nursing care allocations.

The Committee on Trauma Research (1985) states research is needed to determine costs for both short- and long-term injuries. If trauma care is to keep pace, more funds and training need to be directed to trauma nursing (O'Connell-Smeltzer, 1988). Level I trauma center ICUs must have a nurse-to-patient ratio of 1:2 of technically proficient nurses each shift (American College of Surgeons, 1979, 1983). That is a high commitment of nursing time. An evaluation of nursing allocations needs to be completed to determine if there are resources to continue to meet the demands for trauma nurses.

Research Questions

The purpose of this study was to determine if scoring systems that are used to triage trauma victims can be used to predict the nursing costs of trauma care. Specifically, the following research questions were developed:

1. Can the Glasgow Coma Score be used to predict the costs of nursing care for trauma patients during acute hospitalization?
2. Can the Trauma Score be used to predict the costs of nursing care for trauma patients during acute hospitalization?
3. Can the Revised Trauma Score be used to predict the costs of nursing care for trauma patients during acute hospitalization?
4. Can the CRAMS Scale be used to predict the cost of nursing care for trauma patients during acute hospitalization?
5. Can the Injury Severity Score be used to predict the cost of nursing care for trauma patients during acute hospitalization?

Operational Definitions

For the purposes of this study, the following terms are defined.

1. Trauma patient: one who is airlifted to the study hospital, either by helicopter directly from the scene of an accident, or by airplane from another hospital, referred for Level I trauma center care.
2. Acute hospitalization: begins with admission to any nursing unit within the acute care facility and ends with death or discharge from the hospital or release to a rehabilitation center.

Limitations

The following limitations were identified in this study.

1. Only patients referred to a Level I trauma center for care were evaluated.
2. Patients who were dead on arrival, who died in the emergency department, or were discharged from the emergency department were excluded. There is no nursing acuity if the patient is not hospitalized.
3. No nursing costs from Lifeflight or the Emergency Department were identified or analyzed.
4. No rehabilitation costs were evaluated.

5. Burn patients were excluded. There is a burn center in a neighboring trauma center.
6. Patients who were under 18 years of age were excluded. There is a nearby children's hospital that provides care for trauma victims who are children.
7. No distinction was made on the basis of age, sex, or the time interval between occurrence of the trauma and the treatment.
8. No distinction was made for length of hospitalization or for outcome.
9. The scores were not compared to discover whether one score was better than another for prediction of costs.
10. Other functions of trauma scores -- triage, morbidity, mortality -- were not evaluated.

CHAPTER II

REVIEW OF LITERATURE

Trauma

The Center for Disease Control (1982) states trauma accounts for the loss of more potential years of life in the United States than cancer and heart disease, the two major recognized health concerns. Shires, Jones, and Perry (1984) declare there are more than 60 million people injured in the United States each year. They also state there are in excess of 150,000 deaths from those injuries, and more than two permanent disabilities for every death. Treatment for trauma requires more time in an ICU, a longer length of stay (LOS) in the hospital, and is more costly than for any other major health problem, with more than $80 billion being spent each year for the care of accident victims (Cone & Eisner, 1989; Kenner et al., 1985). Excluding those who die immediately, the resultant consequences for the victims depend largely on three factors: (a) the severity of the injury, (b) the length of time before care is received, and (c) the specialization of that care (Committee on Trauma Research, 1985; Trunkey, 1983).

Level I Trauma Centers

The American College of Surgeons established guidelines for Level I trauma centers (1979) in order to provide advanced trauma care. These centers must have emergency room personnel qualified in the care of critically injured patients, with extensive equipment available. Level I trauma centers must have general surgeons and a neurosurgeon available at all times, with other surgical specialists immediately accessible from outside the hospital. They must have ICUs with a nurse-patient minimum ratio of 1:2 during each shift.

In an evaluation of critically injured patients treated at a Level I trauma center versus full-service community hospitals, Clemmer, Orme, Thomas, and Brooks (1985) found those at the trauma center had better survival rates. Similar findings were reported in other studies (Cales, 1984; West, Cales & Gazzanga, 1983; West, Trunkey & Lim, 1979).

Air Transport

Air evacuation of trauma patients has become an accepted component of care for severely injured patients. Helicopters decrease the length of time between an accident and the time specialized interventions can begin (La-Puma & Balskus, 1988; Sharar, Luna, Rice, Valenzuela & Copass, 1988). Fixed-wing transport also provides time-saving trauma care to victims in remote areas.

In a study of trauma patients who were initially operatively stabilized at Level III hospitals and subsequently transferred to a Level I trauma center, Sharar et al. (1988) determined there was no difference in survival for the air transported patients than for those with immediate access to a Level I trauma center. They claim air transport extends trauma care to isolated areas.

Moylan, Fitzpatrick, Beyer, and Georgiade (1988) looked at age, trauma scores, mechanism of injury, and organ systems injury and found that air transported patients had better survival rates than ground transported patients.

Severity of the Injury

In order to ensure that the most severely injured patients reach a Level I trauma center, various triage scores have been implemented to gauge the severity of injuries. These scores range from physiological and clinical to anatomical criteria and include the Glasgow Coma Score (Teasdale & Jennett, 1974), the Trauma Score (Champion et al., 1981), the Revised Trauma Score (Champion et al., 1989), the CRAMS Scale (Gormican, 1982), and the Injury Severity Score (Baker & O'Neill, 1976; Baker et al., 1974).

Glasgow Coma Score

Teasdale and Jennett (1974) produced a physiological scoring system, the Glasgow Coma Score (GCS), which assesses impaired consciousness and coma. Previous existing systems lacked specificity, describing only general characteristics. There was no objective method to delineate patients' level of consciousness. Misunderstandings occurred when patients were referred to other facilities or when patients from different institutions were compared.

The GCS provides a patient's best response in three areas: eye opening, verbal response, and motor response. The highest score possible, 15, would mean the patient opens his or her eyes spontaneously, speaks appropriately, and can move upon command. The lowest score possible, 3, would mean the patient does not open his or her eyes, does not speak, and does not respond to painful stimuli (Table 1).

When the GCS was tested in the cities of New York, Newcastle upon Tyne, and Rotterdam, interrater reliability was higher than 95%. Because the GCS can be assessed easily with little expertise and has a high interrater reliability, both in the field and in the hospital, it has been incorporated into other trauma scoring systems, including the Trauma Score and the Revised Trauma Score.

Table 1

Glasgow Coma Scale

Criteria		Value
A.	Eye opening:	
	Spontaneous	4
	To voice	3
	To pain	2
	None	1
B.	Verbal response:	
	Oriented	5
	Confused	4
	Inappropriate words	3
	Incomprehensible sounds	2
	None	1
C.	Motor response:	
	Obeys commands	6
	Localizes pain	5
	Withdrawal from pain	4
	Flexion from pain	3
	Extension from pain	2
	None	1

Points range from 3 to 15. The worst score is 3, while the best score is 15.

GCS = A + B + C.

Trauma Score

Champion et al. (1981) produced the physiological Trauma Score (TS), which was later endorsed by the American Trauma Society. The TS assesses the physiological and clinical findings of respiratory rate, respiratory effort, systolic blood pressure, capillary refill and includes the GCS with a coded value. The highest score, 16, would mean the patient is breathing 10-24 times a minute, with normal effort, has a systolic blood pressure greater than 90 mmHg, a normal capillary refill, and a GCS of 14 or 15. The lowest score, 1, would mean the patient has no respiratory rate, no respiratory effort, no systolic blood pressure, no capillary refill, and a GCS of 3 or 4 (Table 2).

Champion et al. retrospectively analyzed a computer data bank of 2000 injured patients. The patient information had been previously validated for accuracy. The study showed the TS is a valid and reliable index of injury severity. The TS can be executed at the scene of an accident and used for reassessment during continued care. The TS has been used in the United States since its inception.

Revised Trauma Scale

In an effort to simplify the TS for more effective triage, Champion et al. (1989) revised the TS to make it the Revised Trauma Score (RTS). It eliminates respiratory

Table 2

Trauma Score

Criteria		Value
A.	Respiratory rate:	
	10 to 24 per minute	4
	25 to 35 per minute	3
	36 or greater per minute	2
	1 to 9 per minute	1
	Absent	0
B.	Respiratory expansion:	
	Normal	1
	Intercostal muscle retraction or use of accessory muscles	0
C.	Systolic blood pressure (mmHg):	
	90 or more	4
	70 to 89	3
	50 to 69	2
	0 to 49	1
	No pulse	0
D.	Capillary refill:	
	Normal	2
	Delayed	1
	Absent	0
E.	Glasgow coma score:	
	14 to 15	5
	11 to 13	4
	8 to 10	3
	5 to 7	2
	3 to 4	1

Points range from 1 to 16, with 1 being the worst and 16 being the best. TS = A + B + C + D + E

Note. Reprinted with permission of the Williams and Wilkins Company. Champion, H.R., Sacco, W.J., Carnazzo, A.J., Copes, W.S., & Fouty, W.J. (1981). The trauma score. _Critical Care Medicine_, _9_, 672. Copyright © Williams and Wilkins (1981).

effort and capillary refill categories, stating they were difficult to assess in the field in poor light. It assesses the same other physiological and clinical information, but reassigns the points accrued in the other areas (Table 3).

The RTS was developed from a data base with 2,166 patients. It was tested for validity against 26,000 trauma patients from trauma centers in the United States and Canada. The RTS has not yet been reported in any studies since its initial development and release by Champion et al. in 1989.

CRAMS

Gormican (1982) developed CRAMS, an acronym for Circulation, Respiration, Abdomen, Motor, and Speech, to determine a definition of major trauma. It combines physiological and clinical criteria. It assesses the presence and quality of vital signs, abdominal or chest pain, motor abilities, and the quality of speech. The highest score, 10, would mean the patient has normal capillary refill and a systolic blood pressure greater that 100 mmHg, normal respiration, nontender thorax and/or abdomen, normal motor movements, and appropriate speech. A score of 0 indicates no capillary refill or systolic blood pressure less than 85 mmHg, absent respiration, rigid abdomen or flail chest, no motor response or decerebrate posturing, and no intelligible

Table 3

Revised Trauma Score

A Glasgow Coma Scale	B Systolic Blood Pressure	C Respiratory Rate	Coded Value
13-15	>89	10-29	4
9-12	76-89	>29	3
6-8	50-75	6-9	2
4-5	1-49	1-5	1
3	0	0	0

The best score is 12, with 0 being the lowest score.
RTS = A + B + C.

Note. Reprinted with permission of the Williams and Wilkins Company. Champion, H., Sacco, W.J., Copes, W.S., Gann, D.S., Gennarelli, T.A., & Flanagan, M.E. (1989). A revision of the trauma score. The Journal of Trauma, 29 (5), 623-629.

words (Table 4).

There were 1,723 patients in the initial study. The CRAMS provided a reliable method of calculating which patients should be transported to a Level I trauma center. The CRAMS resembles the TS, is valid and reliable, and is easy to remember. However, except for its use in Utah, as part of the Emergency Medical Systems protocol since 1986, it has not gained wide acceptance throughout the country.

Injury Severity Score

In 1974, Baker, O'Neill, Haddon, and Long extended the Abbreviated Injury Score (AIS) previously developed by the American Medical Association (1971) into an anatomical scoring system, the Injury Severity Score (ISS). The AIS, updated in 1980 and 1985, ranked individual injuries from 1 to 6, with a score of 1 representing a minor injury and a score of 6 representing a lethal injury. The AIS did not provide a way to incorporate multiple injuries into the data base. If there were more than one injury, the AIS did not allow a combination score; the ISS overcame that inadequacy. The ISS provides information about multiple injuries sustained by a trauma victim by summing the scores for injuries to different parts of the body (Table 5).

When studying 2,128 motor vehicle accident victims, Baker et al. (1974) found that mortality increases disproportionately with multiple site injuries. They

Table 4

CRAMS Scale

Criteria		Value
A.	Circulation:	
	normal capillary refill and SBP > 100	2
	delayed capillary refill or 85 < SBP < 100	1
	no capillary refill or SBP < 85	0
B.	Respiration	
	normal	2
	abnormal	1
	absent	0
C.	Abdomen	
	abdomen and thorax nontender	2
	abdomen or thorax tender	1
	abdomen rigid or flail chest or penetrating wounds to the abdomen or chest	0
D.	Motor	
	normal	2
	responds only to pain (other than decerebrate)	1
	no response or decerebrate	0
E.	Speech	
	normal	2
	confused	1
	no intelligible words	0

10 is the best score. 0 is the worst.

CRAMS = A + B + C + D + E.

Note. SBP = systolic blood pressure.

Table 5

Injury Severity Score

Body Regions	Criteria
Head or neck	Brain, skull or cervical spine fractures, and ears
Face	Mouth, eyes, nose and facial bones
Chest	All lesions to internal organs. Also diaphragm, rib cage, and thoracic spine
Abdomen/Pelvis	All lesions to internal organs. Also lumbar spine.
Extremities	Includes shoulder girdle. All amputations, pelvic girdle fractures, dislocations and sprains, except for the spinal column, skull and rib cage.
External	Lacerations, contusions, abrasions, and burns, independent of their location on the body surface.

AIS	Severity Code
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Maximum injury virtually unsurvivable

An ISS of 75 is the worst possible score. Injuries coded AIS-6 are automatically assigned as ISS of 75. To figure the ISS, sum the squares of the highest AIS grades from the three most severely injured areas.

ISS = A squared + B squared + C squared

Note. Adapted from Committee on Injury Scaling (1985).

discovered that squaring the AIS scores for the three most severely injured body areas resulted in an accurate portrayal of mortality expectations. For example, if a patient sustains a major laceration of the liver (a score of 5), a simple rib fracture (a score of 2), a cervical spine fracture without cord involvement (a score of 3), and a laryngeal fracture with airway obstruction (a score of 4), his or her ISS would be the sum of the three highest squared scores: (5x5=25) + (4x4=16) + (3x3=9) for a total score of 50.

Semmlow and Cone (1976) used the ISS to evaluate 8,852 trauma patients where only 38% were victims of motor vehicle accidents. They found results similar to those reported by Baker et al. (1974).

While physiological scores do not account for absolute injury, the ISS identifies the actual anatomical injuries. It is recognized as the "gold standard" for rating injury severity and other trauma scores are compared to it for correlation. The ISS can be calculated within 24 hours of hospitalization when the full extent of injury is identified.

With the exception of the Revised Trauma Score, other investigators have examined the use of these scoring systems in their research. For example, Schwab et al. (1988) found the ISS corresponded to LOS and total hospital costs; Thomas (1987) compared the GCS, the TS, the CRAMS scale, and the ISS, and found close correlation between the scores, mortality, and total hospital costs; Weingarten, Wainwright, and Sacchetti (1988) evaluated TS, LOS, age, mechanism of injury, and gross financial charges, and found that the TS correlated with the daily charges.

Although other trauma scoring systems have been and are currently being used to measure the severity of trauma, they are beyond the scope of this study.

Nursing Costs

Until recently, hospital accounting procedures did not separate nursing costs from total patient care cost (Mowry & Korpman, 1987). Because of the current competitive health care environment, nursing executives recognize the need to separate nursing costs from other charges. In order to gain control of diminishing health care dollars and to document that nursing care is revenue productive, rather than being a cost liability (Edwardson & Giovannetti, 1987), nursing administrators need to be able to determine and predict the cost of nursing care accurately.

A 1983 American Nurses' Association survey showed hospitals were trying to implement separate nursing charges (ANA, 1984). The DRG prospective payment system introduced an added incentive for nursing executives to separate nursing labor costs from traditional "room and board" charges.

Identifying nursing costs has been difficult because of the expense necessary to develop nursing cost allocation methods (Ginsburg & Browning, 1985). However, since numerous researchers reported variations in nursing costs within any given DRG (Barhyte & Glandon, 1988; Rosenbaum, Willert, Kelly, Grey & McDonald, 1988; Wilson et al., 1988), there needs to be further clarification of nursing costs in order to provide accurate data.

Methods to Determine Nursing Costs

There are four major approaches used to determine nursing costs: (a) per diem (cost per day of service), (b) cost by diagnosis, (c) cost by relative intensity measures (RIMs), and (d) cost by patient classification systems (nursing workload unit) (Edwardson & Giovannetti, 1987).

Per diem. Distribution of nursing costs is determined by dividing the total nursing costs by the number of patient days during a designated period of time. The figure obtained is projected to the next year's operating budget in order to charge similar patients. Per diem is included in the traditional procedure of "room and board" charges for hospital care.

With the per diem method, the cost of nursing care is divided by the total patient days, assuming that the cost each day is identical. Per diem methods have been criticized since patient days are not alike and require variable nursing care for different types of patients

(Edwardson & Giovannetti, 1987).

Diagnosis-based cost. Diagnosis-based methods define costs for nursing care within a single diagnosis. From a logistical standpoint, the numbers are currently overwhelming. The DRG system attempts to reduce the 10,171 medical diagnoses in the International Classification of Diseases-9th Revision (ICD-9) to 468 groups. Because of the diversity of medical diagnoses, diagnosis-based methods would only be effective in settings where there were few variations in types of patients.

Halloran, Kiley, and England (1988) compared medical diagnoses (DRGs) with nursing diagnoses to see how well each could predict the costs of care, based on the length of stay. They found that DRGs explained 5.8% of the variation in patients' hospital length of stay, while nursing diagnosis explained 45% of the variations. However, implementation of nursing diagnoses has been hampered by confusing terms and misunderstandings (Sanford, 1987). Nursing diagnoses are in their infant state and have not yet been finalized (Guzzetta, Bunton, Prinkey, Sherer & Seifert, 1989, p. 437). Nursing diagnoses have great potential, but are currently ineffective for predicting costs of care consistently.

Relative intensity measures. RIMs were developed because of a concern that DRGs are not accurate in reflecting differences of patient acuity within diagnostic groupings. The RIMs quantifies patient care time by DRG and distributes values to 13 Nursing Resource Clusters. It was intended to show a relative intensity course for each patient that correlates to the nursing care provided (Caterinicchio, 1983; Grimaldi & Micheletti, 1983)

When the reported minutes of nursing care were regressed against the number of diagnoses and procedures, and the length of stay to calculate costs, the only significant predictor was length of stay. Additionally, Grimaldi and Micheletti (1983) and Trofino (1985) state that since the equations become outdated with changes in practice or average lengths of stay, they are not consistent. Therefore, RIMs do not provide a valid method of measuring nursing costs.

Patient classification system. The nursing workload classification system, later called the patient classification system (PCS), was initially developed to determine nurse staffing needs. It demonstrated the potential for use in determining charges for nursing care, and has been implemented in numerous centers. It converts patient nursing care needs to an index for which monetary costs can be calculated (Nyberg & Wolff, 1984; Riley & Schaefers, 1983). The PCS has been reported in increasing numbers of publications (Barhyte & Glandon, 1988; Reschak, Biordi, Holm & Santucci, 1985).

Edwardson and Giovannetti (1987) assert that information from the PCS needs to be incorporated into individual patient medical records if the data are to be used for cost accounting. They claim fully automated patient records via computer would fulfill the ultimate goal of a system that would integrate all appropriate clinical and financial information.

Such a method was developed at the site of the present study. The fully automated PCS identifies actual nursing care provided to each patient. It was produced as part of the HELP™ (Health Evaluation through Logical Processing) system, a computer-based extensive patient-care system (Johnson, Wigertz & Pryor, 1987; Pryor, Gardner, Clayton & Warner, 1983).

The automated nursing acuity system is interrelated with other nursing application software. When the nurse enters his or her nurses' notes (nursing notes are computerized), the computer sends the patient care activities to the acuity file. These activities include baths and linen changes, vital signs, and medications, each of which has been allotted a standard time. For procedures that may vary in time, such as dressing changes or emotional support, the nurse enters the time spent when he or she charts the procedure (i.e., chest tube dressing change, time spent 10 minutes). Time is spontaneously generated by the computer for indirect care such as charting, report, and preparing care plans (Budd &

Propotnik, 1989).

At the end of each shift, the computer totals the hours of care for each patient. The information can be reviewed to examine nursing's cost governed by DRGs. However, it's main purpose is to provided direct billing charges for nursing care and to calculate staffing needs for the next shift.

During the initial implementation of the nursing acuity system, extensive reliability and validity tests were carried out to assure accuracy. Time and motion studies were done for validation.

Standard management engineering techniques under the direction of a hospital management engineer were utilized during the initial implementation of the automated acuity system. Validity testing included weekly chart audits and time and motion studies. Random charts continue to be audited regularly, with a resultant 90% accuracy (Budd, Blaufuss & Harada, 1988; Budd & Propotnik, 1989).

Patients have been charged for actual nursing care since the inception of the automated nursing acuity system in April of 1986 (Budd et al., 1988; Budd & Propotnik, 1989). Table 6 provides an example of some automated acuity data from an imaginary audit trail. Further information about the Automated Acuity System is available from 3M Health Information Systems, 575 W. Murray Blvd. P.O. Box 7900, Murray, Utah 84157-9900.

Table 6

Automated Nursing Acuity

Acuity Measures	
40266381	STRI 4/12/89 06:01 JEFFERY NMI

FOLEY CATHETER URINE=====ML.
PH=====
SPECIFIC GRAVITY=====
WOUND DRAINAGE #1=====ML
PORTABLE X-RAY X=====
SPECIAL PROCEDURE=====MIN.
#1 INSERTION=====FR.
NG TUBE DRAINAGE=====ML
BLOOD GAS, BLOOD TYPE=====
RESPIRATORY RATE (PER MIN)=====
STO2 (EAROX)=====
IVAC X=====
TEACHING =====MIN
REPOSITIONED=====
SUCTIONED, ARTIFICIAL AIRWAY X=====
ROUTINE ORAL CARE======
ROUTINE SKIN CARE======
CENTRAL LINE======
EMOTIONAL SUPPORT=====MIN
OTHER LINEN CHANGE=====
ARTERIAL LINE CHECKED AND PATENT
FIO2 SETTING=====%
SPONTANEOUS RESPIRATORY RATE====MIN
POSITIVE END EXPIRATORY PRESSURE (PEEP) LEVEL=====
IV=====
NASOGASTRIC=====
INTRAVENOUS=====
INTRAMUSCULAR=====
RECTAL=====
AMINOSYN 8.5%=====ML

10.9 HR, 94% RN full shift

Note. Automated Acuity Data Audit Trail for an Imaginary Patient. Displays items from 12-hour computerized nurse's notes that are transferred to the patient's acuity file for determination of the minutes of care, for which the patient is charged. STO2 is a test of ear oxygenation.

Summary

There are a variety of trauma scoring systems in current use that triage trauma patients for transportation to the appropriate facility. Nursing acuity systems have been implemented that make it possible to charge for nursing care.

While there is a considerable body of literature on the problems of nursing costs, little is available on actual costs. Although the present literature can be used for inferences, concrete costs are necessary to provide sound argument. Precise cost knowledge is important to identify constraints, discuss approaches, and for implementation of new methods. This study was designed to use an automated nursing acuity system already established in a Level I trauma center to identify the actual nursing costs for trauma patients as they relate to the severity of injury defined by currently used trauma scores.

CHAPTER III

METHODOLOGY AND PROCEDURES

Setting

The study site is a 520-bed teaching university-affiliated Level I trauma center, which serves a large geographical area. It has a computer network, the HELP™ System. HELP is an extensive patient-care system that utilizes expert-system technology and incorporates an automated nursing acuity system. The nursing acuity system determines charges for nursing care by extracting information from the patients' records. After the nursing time and charges data are generated, the information is transferred to the accounting computer bank.

Subjects

The study patient population consisted of 448 trauma patients who were aeromedically transported, either by helicopter or airplane, to the study hospital from April 1, 1986 to June 30, 1989. The aeromedically transported patients were a population of critically injured patients who were directed to the Level I trauma center by trauma field scores or by health care personnel from other hospitals.

Eligibility Criteria

Patients who were under 18 years of age were excluded, as there is a nearby children's facility, to which they are transported. Since a burn unit is at a neighboring facility, all burn patients were excluded. As nursing acuity is not recorded until after admission to an ICU or to a regular patient unit, patients who were declared dead on arrival, who died in the Emergency Department or were discharged from the Emergency Department were excluded. No nursing costs from Lifeflight, the Emergency Department, or rehabilitation were identified. No distinction was made as to the age or sex of the patients, nor to the time interval between the occurrence of the trauma and the treatment.

Instruments/Tools

The Automated Acuity System in place at the study site was used to supply nursing costs. During its initial implementation, reliability and validity tests were performed. Regular audits of random charts continue to demonstrate greater than 90% accuracy. During the period of time covered by this study, the average nursing cost was $0.36 a minute.

The Glasgow Coma Score, the Trauma Score, the Revised Trauma Score, the CRAMS scale, and the Injury Severity Score were the trauma scoring tools studied. These scoring systems were selected for the following reasons: (a) the GCS, and CRAMS were already calculated for this population; (b) the TS has been endorsed by the American Trauma Society; (c) the RTS needs to be validated in additional studies as a replacement for the TS; (d) the ISS is currently being calculated on trauma patients at the study site and identifies the actual injuries; (e) other scoring systems are not as widely quoted in the literature; and (f) these scoring systems are frequently used or acknowledged, providing a common ground for discussion among trauma health care professionals.

Design

This study utilized a retrospective design. It was designed to determine if trauma scoring systems can predict nursing costs for trauma patients at a Level I trauma center. It covered the period of April 1, 1986 to June 30, 1989. The independent variables included the following trauma scoring systems: the Glasgow Coma Score; the Trauma Score; the Revised Trauma Score; the CRAMS Scale; and the Injury Severity Score. The dependent variable was Nursing Cost of trauma patients, as calculated by the automated acuity system.

All data for the scoring systems were extracted from the records by the same researcher. The data from the trauma scoring systems were collected by audit of patients' State emergency medical services records, flight logs, and patients' charts. All financial data were retrieved from the accounting computer and the automated nursing acuity were retrieved from the clinical computer. After the data had been gathered, the researcher reviewed the data sheets to verify their accuracy. When the data were reentered into the computer, a computer search by the Statistical Package for Social Sciences was carried out to detect any errors in transcription.

Quantitative analysis was used to determine frequency distributions for patients in each category of each of the scoring systems. In order to provide larger groups for more powerful parametric statistical analysis, consecutively aligned small categories of scores were combined to provide at least 20 patients in each group (Wilson, 1985, p. 454).

In order to calculate correlational relationships, the relationships must be linear (Munro, Visintainer & Page, 1986, p. 64). Since a nonlinear relationship existed for these data, analysis by correlational techniques was inappropriate for this study.

A one-way analysis of variance (ANOVA) is an inferential parametric statistical test that compares two or more groups to determine if there is a difference between groups. A significant F test would determine that the groups were different. The assumptions of ANOVA are that the dependent variable will be continuous data, the groups will be mutually exclusive, the dependent variable will be normally distributed, and the groups will have equal (homogenous) variance (Munro et al., 1986, p. 176). If there is a difference between groups in the trauma scoring systems, then the inference can be made that the nursing costs for patients who belong to a particular group in each scoring system will be different than the nursing costs for patients in other groups.

When ANOVA is performed by the Statistical Package for the Social Sciences (SPSS), an added advantage is that the computer can also run further statistical tests to determine even more closely the variance and difference of groups within a scoring system. Cochran and Bartlett's tests were performed to check for homogeneity of variance. Multiple range tests were performed, using the Student-Newman-Keuls (SNK) posthoc procedure to further calculate and identify the differences between groups in a single scoring system. The total population was also separated by helicopter versus airplane transport to determine if there was a difference for nursing costs between these two modes of transportation.

Glasgow Coma Score

Research question one asked,

> Can the Glasgow Coma Score be used to predict the costs of nursing care for trauma patients during acute hospitalization?

The GCS is routinely applied on trauma patients in Utah and is recorded on the state Emergency Medical System form. All GCSs were obtained for this study by a review of the patients' flight logs and EMS forms, as scored by a Flight Nurse or Paramedic.

In order to perform a more powerful statistical analysis, scores from consecutive categories were combined to obtain groups of at least 20 patients. Scores of 3 and 4, measuring those most severely injured, were combined. Scores of 5 and 6 were combined. Scores of 7,8, and 9 were combined. Scores of 10 and 11 were combined. Scores of 12 and 13 were combined. The scores of 14 and 15 had enough patients ($\geq$ 20) and were left by themselves.

<u>Trauma Score</u>

Research question two asked,

> Can the Trauma Score be used to predict the costs of nursing care for trauma patients during acute hospitalization?

As the TS is not used by the Emergency Medical System in Utah, the TS was calculated from an audit of each patient's state EMS form and flight log, where the necessary information was derived for computation of the TS.

For more powerful statistical results, scores were combined from small sequential categories into groups with at least 20 patients. Scores of 1 through 6, representing those most severely injured, were combined. The score of 7, which had 46 patients in it, was left alone. Scores of 8,9, and 10 were combined. Scores of 11, 12, and 13 were combined. The scores of 14, 15, and 16 each had enough patients to be left separate.

Revised Trauma Score

Research question three asked,

> Can the Revised Trauma Score be used to predict the costs of nursing care for trauma patients during acute hospitalization?

To calculate the RTS for this study, the flight log and each patient's state EMS form was audited, whereupon the corresponding information was obtained for computation of the RTS.

To provide more meaningful statistical data, scores from smaller sequential categories were combined to form groups of at least 20 patients. Scores 0 through 4, those most severely injured, were combined. The scores of 5 and 6 were left alone. The scores of 7, 8, and 9 were combined. Each of the scores 10, 11, and 12 had more than 20 patients in them and were left alone.

CRAMS Scale

Research question four asked,

> Can the CRAMS Scale be used to predict the costs of nursing care for trauma patients during acute hospitalization?

The CRAMS has been measured by a Flight Nurse or Paramedic on trauma patients in Utah since 1986 and is recorded on the state EMS form. Each patient's EMS form and flight log was audited to obtain the information for this study.

To provide better statistical analysis, the small categories of 1, 2, and 3 -- the most severely injured patients -- were combined to form a group of at least 20 patients. All other scores were left by themselves, as there were more than 20 patients in each of these categories.

Injury Severity Score

Research question five asked,

> Can the Injury Severity Score be used to predict the costs of nursing care for trauma patients during acute hospitalization?

The ISS can be calculated within 24 hours of hospitalization, when the full extent of injury is identified. For this study, the ISS was obtained by a review of patient chart discharge summaries.

For statistical analysis, scores were combined into groups to provide at least 20 patients in each group. Scores 1 through 9 -- the least injured -- were combined. Scores 10 through 19 were combined. Scores 20 through 29 were combined. Scores 30 through 39 were combined. Scores of 40 through 49 were combined. Scores of 50 through 75 representing patients who were most severely injured were combined.

Summary

In order to determine if trauma scoring systems can predict the nursing cost of trauma care, the Glasgow Coma

Score, the Trauma Score, the Revised Trauma Score, the CRAMS scale, and the Injury Severity Score were compared to the nursing costs for 448 trauma patients who were aeromedically transported to the study site, a Level I trauma center. After quantitative analysis calculated the frequency distributions for patients in each category of each of the scoring systems, smaller categories were combined for statistical analysis.

One-way Analysis of Variance was used to determine a significant *F* level. Cochran and Bartlett's tests for homogeneity were run. Student-Newman-Keuls multiple range tests were performed to determine which groups differed statistically from each other with the various scoring systems.

CHAPTER IV

RESULTS

The purpose of the study was to determine if trauma scoring systems can predict the nursing costs of trauma care. The Glasgow Coma Score, the Trauma Score, the Revised Trauma Score, the CRAMS Scale, and the Injury Severity Score were the trauma scoring systems that were utilized. Nursing costs were derived by the Automated Nursing Acuity System.

After quantitative analysis was calculated for the population breakdown in each scoring system, small consecutive categories were combined in order to have at least 20 patients in each group for more powerful statistical analysis. Because the data are curvilinear, correlation techniques were not used for statistical analysis.

Each trauma scoring system and nursing cost for the 448 patients was analyzed via the Statistical Package for Social Sciences for a significant F test ($p \leq 0.0000$) by one-way analysis of variance (ANOVA). Cochran and Bartlett's tests for homogeneity were run.

Additional posthoc procedures were performed by way of the Student-Newman-Keuls tests for each scoring system to determine which groups within each scoring system differed significantly from each other. Student-Newman-Keuls procedures show significance to the 0.05 level.

For the 248 patients who were transported by helicopter and the 200 who were transported by airplane, the differences for nursing costs were not statistically significant ($p = 0.2103$). Therefore, the remaining analysis represents all 448 patients.

Glasgow Coma Score

Research question one asked,

> Can the Glasgow Coma Score be used to predict the costs of nursing care for trauma patients during acute hospitalization?

Data from the groups of scores for the GCS and the nursing costs were analyzed using one-way ANOVA, with a p value of less than 0.0000, which showed the groups in the GCS differed from each other. The summary of ANOVA for the GCS is shown in Table 7. Cochran and Bartlett's tests for homogeneity were nonsignificant; therefore, the assumption of homogeneity was met.

The SNK multiple range test showed nursing costs for GCS scores of 5-6 to be statistically different from all other scores. Nursing costs for scores of 3-4 were significantly different than for scores of 5-6, 12-13, 14, and 15. Nursing costs for scores of 7-8-9 were significantly different than for scores of 5-6, 12-13, and 15. Nursing costs for scores of 10-11 were significantly

Table 7

Summary of ANOVA for Glasgow Coma Score and

Nursing Costs

Source	*df*	Sum of Squares	Mean Squares	*F*	*p*
Between Groups	6	850437442.5	141739573.8	12.5565	.0000
Within Groups	441	4978069750	11288140.02		
Total	447	5828507192			

different than for scores of 5-6 and 15. Nursing costs for scores of 12-13, 14, and 15 were not significantly different from each other. Forty-five percent of the patients fell into the highest (best) score of 15, with 51.4% of all the patients in the groups showing the scores of 12-13, 14, and 15. The mean nursing costs for the GCS are shown in Table 8 and Figure 1.

As ANOVA showed all the groups to be different, it can be inferred that the costs for each group can be calculated as represented in Table 8 and Figure 1. Therefore, the GCS can be used to predict the nursing cost of trauma care.

Trauma Score

Research question two asked,

> Can the Trauma Score be used to predict the costs of nursing care for trauma patients during acute hospitalization.

The data were analyzed using one-way ANOVA, which showed a *p* value of less than 0.0000. A summary of ANOVA for the TS is shown in Table 9. Cochran and Bartlett's test for homogeneity was nonsignificant; therefore, the assumption of homogeneity was met.

Multiple range tests using the SNK procedure showed nursing cost for TS scores of 1-6 to be statistically different than scores of 15 and 16. Nursing costs for a score of 7 was significantly different than for the scores of 13, 14, 15, and 16. Nursing costs for scores of 8-10

Table 8

Glasgow Coma Score and Nursing Cost

Score	_n_	Mean Cost	_SD_	Range
3-4	69	$4,121.74	$4,656.10	$70.11 - $22,941.96
5-6	26	$6,724.74	$5,039.10	$316.93 - $18,479.67
7-8-9	35	$3,822.81	$3,253.54	$129.15 - $12,478.08
10-11	23	$3,953.20	$5,964.41	$191.43 - $27,033.76
12-13	44	$1,909.43	$2,119.88	$67.28 - $11,262.87
14	49	$2,366.99	$4,160.48	$131.61 - $24,625.92
15	202	$1,759.69	$1,869.41	$50.82 - $10,968.32
Total	448			

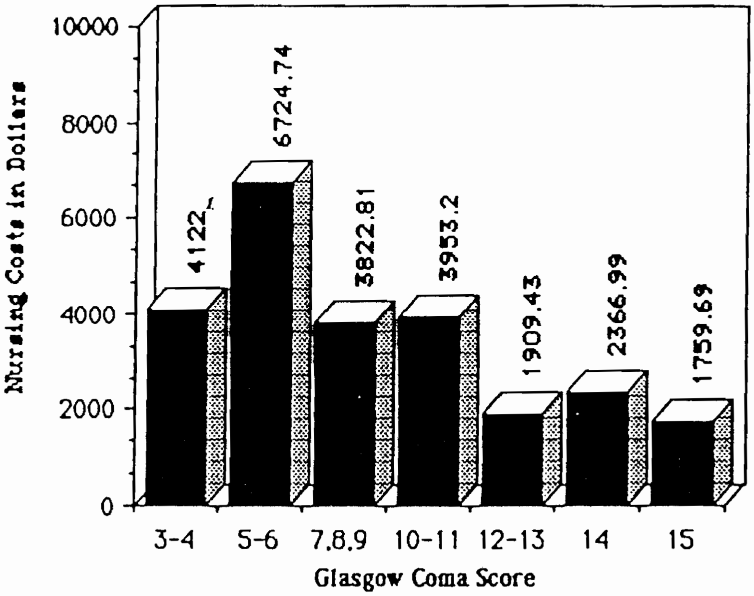

Figure 1. Mean nursing cost for Glasgow Coma Scale.

Table 9

Summary of ANOVA for Trauma Score and

Nursing Costs

Source	*df*	Sum of Squares	Mean Squares	*F*	*p*
Between Groups	6	1096806497	182801082.8	17.0373	.0000
Within Groups	441	4731700696	10729480.04		
Total	447	5828507192			

were significantly different than for scores of 11-13, 14, 15, and 16. Nursing costs for scores of 11-13 were significantly different than for scores of 7 and 8-10. Nursing costs for scores of 11-13, 14, 15, and 16 were not significantly different from each other. Thirty-three percent of the patients fell into the best or highest score of 16, while 65.4% of all the patients had scores of 12-13, 14, 15, and 16. The mean nursing costs for the TS are shown in Table 10 and Figure 2.

Analysis of variance showed all the groups to be different, inferring that the costs for each group can be calculated as represented in Table 10 and Figure 2. Therefore, the TS can be used to predict the nursing cost of trauma care.

Revised Trauma Score

Research question three asked,

> Can the Revised Trauma Score be used to predict the costs of nursing care for trauma patients during acute hospitalization?

One-way ANOVA was performed with the groups of scores for the RTS and the nursing costs with a resultant *p* value of less than 0.0000. The summary of ANOVA for the RTS is shown in Table 11. Cochran's and Bartlett's tests for homogeneity were nonsignificant; therefore, the assumption of homogeneity was met.

The SNK multiple range test showed nursing costs for RTS scores of 1-4 to be statistically different than

Table 10

Trauma Score and Mean Nursing Cost

Score	n	Mean Cost	SD	Range
1-6	33	$4,200.69	$5,309.20	$70.11 - $22,941.96
7	46	$5,709.33	$4,512.31	$178.35 - $17,746.75
8-10	43	$5,326.08	$5,263.68	$316.93 - $27,033.76
11-13	55	$2,796.71	$2,638.26	$128.10 - $11,262.87
14	41	$2,438.35	$2,387.12	$50.82 - $8,983.33
15	79	$1,645.59	$1,710.25	$70.47 - $7,853.97
16	151	$1,492.41	$2,473.66	$67.28 - $24,625.92
Total	448			

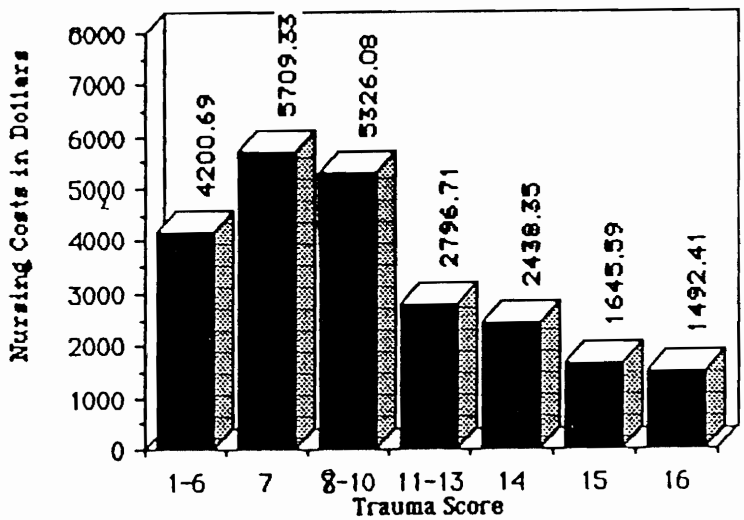

Figure 2. Mean nursing cost for trauma score.

Table 11

Summary of ANOVA for Revised Trauma Score and Nursing Costs

Source	*df*	Sum of Squares	Mean Squares	*F*	*p*
Between Groups	5	994198670.1	198839734.0	18.1799	.0000
Within Groups	442	4834308522	10937349.60		
Total	447	5828507192			

scores of 5, 11, and 12. Nursing costs for a score of 5 were significantly different than 1-4, 7-10, 11, and 12. Nursing costs for a score of 6 were significantly different than for a score of 11 or 12. Nursing costs for scores of 7-10 were significantly different than for scores of 5, 11, and 12. Nursing costs for 11 and 12 were not statistically different from each other. Of the patients, 50.9% had a score of 12, while 64.7% were in groups 11 or 12. The mean nursing costs for the RTS are shown in Table 12 and Figure 3.

One-way ANOVA showed all the groups to be different, inferring that the costs for each group can be calculated as represented in Table 12 and Figure 3. Therefore, the RTS can be used to predict the nursing cost of trauma care.

CRAMS

Research question four asked,

> Can the CRAMS Scale be used to predict the costs of nursing care for trauma patients during acute hospitalization?

One-way ANOVA was performed with the groups of scores for CRAMS and the nursing costs with a p value of less than 0.0000. The summary of ANOVA for CRAMS is shown in Table 13. Cochran and Bartlett's tests for homogeneity were nonsignificant; therefore, the assumption of homogeneity was met.

Student-Newman-Keuls paired comparison tests showed

Table 12

Revised Trauma Scale and Mean Nursing Cost

Score	n	Mean Cost	SD	Range
1-4	39	$3,799.11	$5,130.54	$70.11 - $22,941.96
5	27	$6,330.87	$5,231.08	$79.45 - $18,479.67
6	28	$4,967.47	$3,750.62	$256.41 - $13,275.64
7-10	64	$4,265.49	$4,422.32	$128.10 - $27,033.76
11	62	$2,389.52	$2,441.64	$124.00 - $10,753.48
12	228	$1,579.34	$2,247.89	$50.82 - $24,625.92
Total	448			

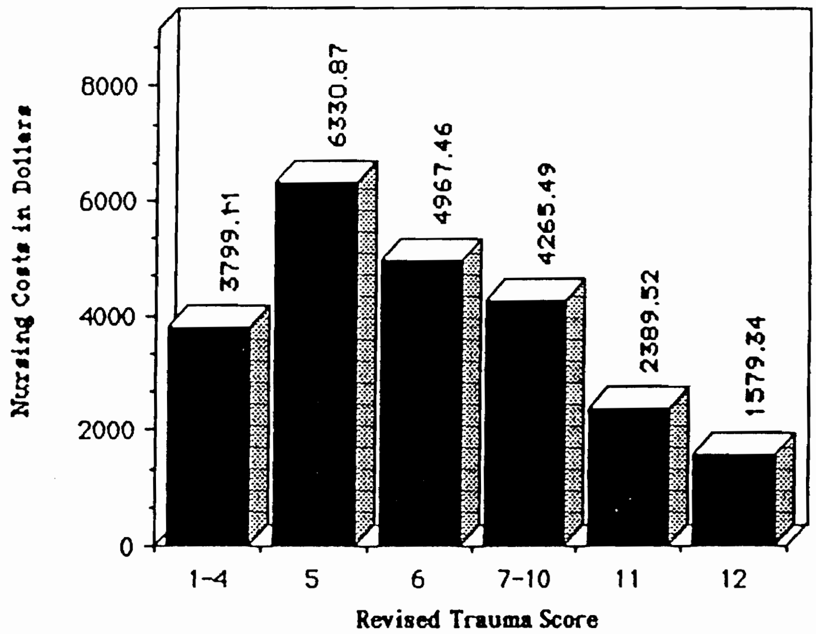

Figure 3. Mean nursing cost for Revised Trauma Score.

Table 13

Summary of ANOVA for CRAMS and

Nursing Costs

Source	*df*	Sum of Squares	Mean Squares	*F*	*p*
Between Groups	7	1060315785	151473683.5	13.9777	.0000
Within Groups	440	4768191408	10836798.65		
Total	447	5828507192			

nursing costs for CRAMS scores of 1-3, 4, 5, and 6 to be significantly different than for scores of 8, 9, and 10, but not significantly different than for each other. Nursing costs for scores of 8, 9, and 10 were not significantly different than each other, though they were significantly different than the scores of 1-3, 4, 5, and 6. The mean nursing costs for the CRAMS are shown in Table 14 and Figure 4. Twenty-two percent of the patients had the highest (best) score, 10, while 59.1% had scores of 8, 9, and 10.

Analysis of variance showed all the groups to be different, inferring that the costs for each group can be calculated as represented in Table 14 and Figure 4. Therefore, the CRAMS can be used to predict the nursing cost of trauma care.

Injury Severity Score

Research question five asked,

> Can the Injury Severity Score be used to predict the costs of nursing care for trauma patients during acute hospitalization?

One-way ANOVA was performed with the groups of scores for the ISS and the associated nursing costs with a *p* value of less than 0.0000. The summary of ANOVA for the ISS is shown in Table 15. Cochran and Bartlett's tests for homogeneity were nonsignificant; therefore, the assumption of homogeneity was met.

Multiple range paired comparison, via the SNK

Table 14

CRAMS and Mean Nursing Cost

Score	n	Mean Cost	SD	Range
1-3	31	$4,538.27	$4,445.30	$70.11 - $13,590.00
4	43	$5,076.20	$5,028.31	$79.45 - $22,941.96
5	36	$5,267.23	$6,003.52	$129.15 - $27,033.76
6	31	$4,447.44	$3,419.14	$256.41 - $11,262.87
7	42	$3,321.91	$4,250.62	$50.82 - $24,625.92
8	65	$1,914.48	$1,668.79	$128.10 - $7,485.36
9	99	$1,687.04	$2,100.42	$69.96 - $10,968.32
10	101	$1,207.79	$1,224.31	$67.28 - $5,900.76
Total	448			

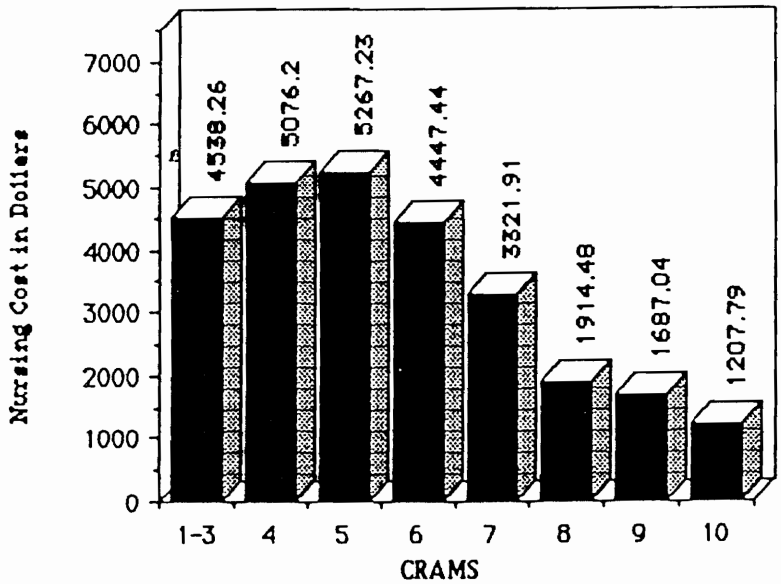

Figure 4. Mean nursing cost for CRAMS.

Table 15

Summary of ANOVA for Injury Severity Score and Nursing Costs

Source	*df*	Sum of Squares	Mean Squares	*F*	*p*
Between Groups	5	1438377823	287675564.6	28.9633	.0000
Within Groups	442	4390129370	9932419.388		
Total	447	5828507192			

procedure, showed nursing costs for ISS scores of 1-9 to be significantly different than for the scores for all other groups except 10-19. Nursing costs for scores of 10-19 were significantly different than those for groups 30-39, 40-49, and 50-75. Nursing costs for scores of 20-29 were significantly different than those for scores of 1-9, 10-19, 40-49, and 50-75. Nursing costs for scores of 30-39 were significantly different than scores of all groups except 20-29. Nursing costs for scores of 40-49 and 50-75 were significantly different than for all other scores. The mean nursing costs are shown in Table 16 and Figure 5. Only 11.9% of the patients fell into the least injured group of scores, 1-9.

Analysis of variance showed all the groups to be different, inferring that the costs for each group can be calculated as represented in Table 16 and Figure 5. Therefore, the ISS can be used to predict the nursing cost of trauma care.

Summary

Groups of scores in each of the trauma scoring systems -- Glasgow Coma Score, Trauma Score, Revised Trauma Score, CRAMS Scale, and Injury Severity Score -- were analyzed for the 448 trauma patients by the inferential parametric statistical test, ANOVA. For each trauma scoring system, a significant $\underline{F}$ test was obtained ($\underline{p}$ = 0.0000), indicating there is a statistical difference in

Table 16

Injury Severity Score and Mean Nursing Costs

Score	n	Mean Cost	SD	Range
1-9	52	$486.06	$447.85	$67.28 - $2,224.20
10-19	80	$1,226.77	$1,571.11	$89.90 - $8,716.75
20-29	107	$1,831.60	$2,252.00	$128.10 - $13,590.00
30-39	66	$2,712.49	$2,584.78	$130.68 - $12,168.99
40-49	58	$4,463.39	$4,196.14	$70.11 - $22,941.96
50-75	85	$5,672.02	$5,128.60	$50.82 - $27,033.76
Total	448			

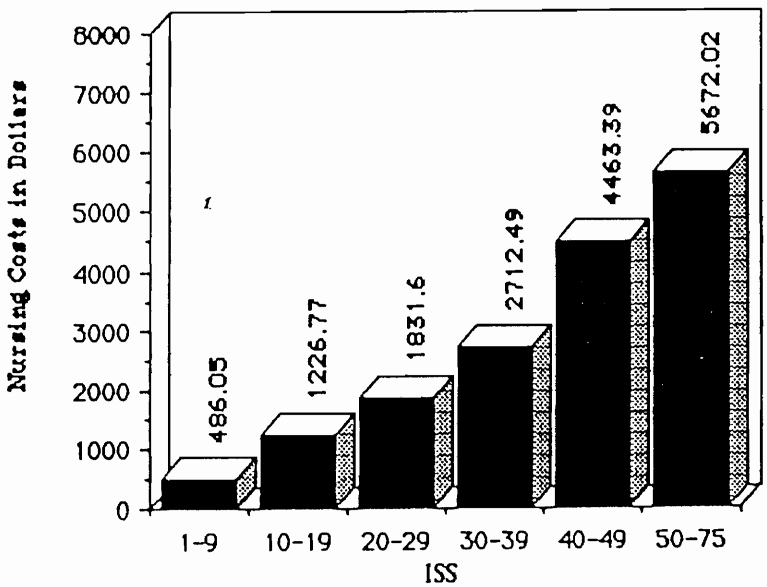

Figure 5. Mean nursing cost for Injury Severity Score.

the nursing costs for different groups. Cochran and Bartlett's tests were run for homogeneity of variance. Student-Newman-Keuls multiple range tests showed additional differences between high scoring groups and low scoring groups in each of the scoring systems. Based on these statistical tests, the answer to each research question was "yes, trauma scoring systems can predict the nursing costs of trauma care."

CHAPTER V

DISCUSSION

The 1966 publication of the National Academy of Science/National Research Council White Paper entitled, "Accidental Death and Disability: The Neglected Disease of Modern Society," brought focus to the trauma crisis that was occurring in this country. The Highway Safety Act and Emergency Medical Services System Act soon provided impetus and guidelines for reducing morbidity and mortality (Boyd, 1982, 1983; Boyd & Cowley, 1983).

Emerging technology spurred the development of trauma centers for improving the care given to trauma victims (American College of Surgeons, 1979, 1983). Triage systems were developed to assess the severity of injury and the need for extensive care (Baker et al., 1974: Champion et al., 1981, 1989; Gormican, 1982: Teasdale & Jennett, 1974).

Along with expanding technology came escalated health care costs. Economic concerns surfaced. Trauma patients have longer hospitalizations and require longer stays in an intensive care unit (Kenner et al., 1985). Nursing costs for trauma patients are correspondingly higher (Mowry & Korpman, 1987). Because of these concerns, the present study was conducted for the purpose of determining if trauma scoring systems could predict the nursing cost of trauma care.

Glasgow Coma Score

Research question one asked,

> Can the Glasgow Coma Score be used to predict the costs of nursing care for trauma patients during acute hospitalization?

According to one-way analysis of variance (ANOVA) for all groups in the GCS, a significant F level was obtained ($p \leq 0.0000$). After Cochran and Bartlett's tests for homogeneity were run, consequent analysis by the Student-Newman-Keuls posthoc test for the 448 patients in the study showed additional significant differences between groups of scores.

As Figure 1 shows, and the SNK stated, those most severely injured, with a GCS of 3 and 4, had significantly lower costs than those with scores of 5 and 6. The patients with scores of 3-4 were more likely to die early in their hospital stay. The patients with scores of 5-6, those who were more likely to survive but remain on ventilators until they have recovered to a point where they can respirate independently, incur significantly higher costs than all other groups.

The nursing costs for the succeeding groups were more closely aligned to the groups immediately preceding and following them. With the exception of the scores of 3-4, as the GCS improves, the nursing costs decline.

With the exception of the scores of 3-4, the SNK posthoc procedure showed a significant statistical difference (0.05) between the low scores, the medium scores, and the high scores. One needs to remember that ANOVA showed each of the groups to be different. Therefore, we can predict that the costs for each group will be as outlined in Table 8 and Figure 1. We can state a score of 3-4 would have a mean cost of $4,121 with a standard deviation of $4,656, on through the scores until a score of 15 would have a mean cost of $1,759 with a standard deviation of $1,869.

Trauma Score

The second research question posed asked,

> Can the Trauma Score be used to predict the costs of nursing care for trauma patients during acute hospitalization?

One-way ANOVA showed a significant *F* level ($p \leq 0.0000$). Following Cochran and Bartlett's tests for homogeneity, multiple range tests via the SNK procedure showed the higher and lower Trauma Scores differed significantly.

As with the GCS, those patients with the lowest TS of 1-6 cost less than the next score, 7, although not significantly. This is the most critically injured population, those more likely to die early in their hospital stay, thereby having lower total nursing costs. The patients with scores of 7 and 8-10 include those who were seriously injured, but who did not die immediately, thereby requiring larger quantities of nursing care. Again, the midrange patients, who were more severely injured cost more, with nursing costs decreasing thereafter as the TS improved. There was a sharp nursing cost break between the higher Trauma Scores of 11 through 16 and the lower Trauma Scores of 1 through 10.

Once again, one needs to remember that although the SNK procedure shows significant differences between the higher and lower scores, ANOVA showed that the groups were all different. Scores of 1-6 would be expected to have a mean nursing cost of $4,200 and a standard deviation of $5,309.20, while a score of 16 would have a mean nursing cost of $1,492. and a standard deviation of $2,473, as is shown in Table 10 and Figure 2.

Revised Trauma Score

Research question three asked,

> Can the Revised Trauma Score be used to predict the costs of nursing care for trauma patients during acute hospitalization?

After the inferential statistical analysis, ANOVA showed a significant $\underline{F}$ level ($\underline{p} \leq 0.0000$), Cochran and Bartlett's tests were run to check for homogeneity. Sequential SNK multiple range tests showed that the higher RTS vary significantly from lower scores.

The patterns set by the RTS closely resemble those of the TS, from which it was revised. Figure 3 shows that the costs for the lowest RTS (1-4) were less than for the next group, 5. These patients were the ones more likely to die early in their hospital stay, with correspondingly lower costs. The score of 5 represents those patients who were not likely to die but who required extensive nursing care. After the score of 5, the nursing costs continued to decline as the scores improved.

As with the TS, there was a significant cost break between the lower scores of 1-10 for the RTS than the higher scores of 11 and 12. Since the RTS removed the clinical values of capillary refill and respiratory expansion from the TS, it is not as specific as the TS, and the break in costs comes later.

Although the SNK posthoc procedure showed the significant differences between the groups, the ANOVA showed that the groups were different. Therefore, nursing costs can be predicted from RTS scores, based on the figures in Table 12 and Figure 3. A score of 1-4 can be expected to have a mean nursing cost of $3,799 and a standard deviation of $5,130, while a score of 12 would have a mean nursing cost of $1,579 and a standard deviation of $2,247.

CRAMS Scale

The fourth research question asked,

> Can the CRAMS scale be used to predict the cost of nursing care for trauma patients during acute hospitalization?

Analysis of variance showed a significant F level ($p \leq$

0.0000), with a corresponding assumption of homogeneity met by the Cochran and Bartlett tests. The SNK posthoc procedure provided assurance that there is a statistically significant difference between the higher CRAMS scores and the lower costs. Accordingly, the CRAMS scale can predict the cost of nursing care.

The path for increased costs for CRAMS follows the same pattern as for the previously discussed scoring systems, but the change from group to group is less dramatic. The poorest scores, 1-3, representing the most severely injured and most likely to die early patients were not statistically different by SNK than those of 4 through 7. Again, after the next most severely injured groups of 4 and 5, as the scores improved, the nursing costs declined. There was a sharp line of demarcation in statistical difference (0.05) between the higher scores -- 8 through 10 -- and the lower scores of 1 through 7.

Analysis of variance showed the groups to be different, while SNK showed which groups were significantly different. A mean nursing cost of $4,538.26 with a standard deviation can be predicted for CRAMS scores of 1-3, with the mean nursing cost of a score of 10 to be $1,207.79 and a standard deviation of $4,445.30 as shown in Table 14 and Figure 4.

Injury Severity Score

The fifth and final research question asked,

> Can the Injury Severity Score be used to predict the cost of nursing care for trauma patients during acute hospitalization?

Analysis by ANOVA showed a significant F level ($p \leq 0.0000$), followed by assurance of homogeneity by the Cochran and Bartlett tests. Subsequent analysis by the SNK procedure showed the lower ISS scores to have significantly different nursing costs than higher ISS scores. Thus, research question five was confirmed.

As the injury severity increased, so did the nursing costs. Patients were more diffusely spread across the possible scores than was evidenced in the other scoring systems. Except for the group to either side, all groups differed significantly (0.05) from one another. It should be pointed out that the ISS is the only scoring system examined where the higher scores represented worst injuries, while the lower scores represented less severe injuries.

The ISS was the only score that showed a linear relationship between the severity of injury and the nursing costs, with a score of 9 or less (least critically injured patients showed a mean nursing cost of $486.06 with a standard deviation of $447.85, while an ISS of 50 or higher showed a mean nursing cost of $5,672.02 with a standard deviation of $5,128.60, as shown in Table 16 and

Figure 5.

General Discussion

In each of the scoring systems except the ISS, better than half the patients fell into the less severely injured scores. These same scores are the one that differed significantly from those of the more severely injured patients, according to the SNK procedure. The ISS scores were spread more diffusely across the scoring scale. Except for the groups adjacent to it, each ISS score differed significantly from all the other scores.

In most of the scoring systems, those groups adjacent to each other were not significantly different by SNK, but as distance increased, the difference was statistically significant. As in other studies that examined costs for particular groups of trauma patients (Bennett et al., 1989; Thomas et al., 1989; Waller, Payne & McClallen, 1989) the standard deviations were large, because of the wide variation in injuries and the possibility of early death or extreme complications. The ISS was the only scoring system to define the actual injuries and had a different pattern of statistical difference from group to group.

Contrary to Mowry and Korpman's assertion (1987) that more severely injured patients would have greater nursing costs in the GCS, the TS, the RTS, and the CRAMS, the group with the most severely injured patients cost less for nursing care than did the next group. Each of these scoring systems includes a measure of level of consciousness. An assumption is that patients in the lower categories of these scoring systems are more likely to die early in their hospital stay, thereby decreasing their overall nursing costs.

The ISS is the only scoring system that measures the actual injuries and does not measure physiological responses. The other scoring systems all measure the clinical findings and physiological responses to injuries. For the ISS, the most severely injured patients did have higher nursing costs, following Mowry and Korpman's (1987) assertion.

When compared to the nursing costs, all of the trauma scoring systems showed a significant statistical difference by SNK (0.05) between the poorer and the better scores. With all the scores, analysis of variance showed the groups to be different ($p = 0.0000$). Therefore, the results from this study have shown that trauma scoring systems can predict the nursing costs of trauma patients.

CHAPTER VI

IMPLICATIONS AND RECOMMENDATIONS

Implications

The fact that trauma scoring systems can predict the nursing costs of trauma care is of vital importance to future planning for trauma centers and for nursing administrators. The ability to predict nursing costs of trauma care from trauma scoring systems provides concrete financial data for determining nursing care allocations.

By examining the data from this study, one can determine the mean nursing cost of care for any group of trauma patients under any of the five scoring systems. In light of 60 million injuries a year in the United States (Shires, Jones & Perry, 1984), the financial concerns are staggering. Although actual figures vary from paper to paper, all agree nursing costs are a large portion of the overall costs (Mowry & Korpman, 1987). The tremendous nursing costs with their associated large standard deviations for trauma patients, as shown by this study, could serve as a disincentive for hospitals to become or remain a trauma center.

According to the Committee on Trauma Research (1985), if trauma care is to keep pace, more funds and training need to be directed toward trauma nursing. Advanced technological nursing skills cost an institution additional money, whether in the course of hiring highly trained nurses, or providing the education for them to become highly trained.

Although the nursing costs identified in this study may not be generalizable to other institutions, the acuity levels from which nursing costs were derived can be applied in other settings. The costs have been represented in dollars for ease in communication. However, the original cost figure is in acuity minutes, which averaged $0.36 a minute, over the period of data collection.

The nursing acuity will help to compute the amount of nursing care a trauma patient will require throughout his or her hospital length of stay. Level I trauma center ICUs must have a nurse-to-patient ratio of 1:2 (American College of Surgeons, 1979, 1983). If nursing shortages continue or escalate, an administration may decide there are not enough nursing resources available to meet the nursing acuity demands of trauma patients.

When reviewing the distress expressed about the DRG prospective payment system, numerous new concerns come to mind. If an institution has a large indigent population, which is unable to pay for services, how long will it be economically feasible to care for trauma patients? If insurance companies were to adopt the prospective payment system, hospitals would lose additional revenues. This researcher looked only at the nursing costs for trauma care. Other costs would be correspondingly high. This study, in light of previous studies, provides justification for a new cost-basis reimbursement schedule for trauma patients.

Recommendations for Future Research

In analyzing whether trauma scoring systems could predict the nursing costs of trauma care, this researcher looked only at aeromedically evacuated patients. A future study should be performed to evaluate ground transported patients' trauma scores and their nursing costs. Replication of this study in other trauma centers that have a nursing acuity tool, or have data upon which to determine nursing costs, would provide additional confirmation of these findings. Studies with larger populations may show significant F values and paired comparison tests between every score in each scoring system, without the need to collapse categories for statistical analysis.

This researcher was concerned with the acute hospitalization financial costs of trauma nursing. Additional studies could expand the base of this study to examine rehabilitation nursing costs for trauma patients.

One set of data that the records included, but which was not considered here, was the outcome (or long-term effects) of trauma for patients. More work needs to be done to explore the holistic problems of trauma patients and their subsequent condition.

Summary

Since the 1966 publication of the National Academy of Science/National Research Council White Paper drew attention to the straits of trauma care, many things have changed. Emergency medical systems have been legislated. Scoring systems to direct trauma patients to the correct facilities have been utilized. Level I trauma centers have been established that provide advanced care by expert health care providers. ICUs are equipped with highly skilled nursing personnel. Technology has improved the care that is available for trauma patients. All of these improvements have brought increased costs.

Technology has also provided the means to examine the costs of trauma care. The information provided by this research project is of immense magnitude due to the circumstances under which it was conducted. The availability of the technology, the data, and the institutional support made it possible to access data that would normally take years to gather.

The automated nursing acuity system that is part of the computer network provided nursing costs from an already proven and reliable tool. The patient charts were reviewed by one person, eliminating the margins for error with interrater reliability issues. The scores were entered into the computer by one person, again eliminating validity questions resulting from numerous personnel. The Glasgow Coma Score and the CRAMS scale were already part of the records, and the information necessary to calculate the Trauma Score and the Revised Trauma Score was included in the GCS and the CRAMS. The information for the Injury Severity Score was already in the patients' charts on a computer printout discharge summary. Such a study would be impossible without such a combination of technology, equipment, and personnel. No other study has been found that was able to utilize such a vast array of tools to examine costs of nursing care. As it is, this study has provided specific costs for trauma patients under various scoring systems, which is timely and of great importance.

Trauma centers that use any of these scoring systems can evaluate the nursing costs presented in this study and relate them to their own institutions. Trauma costs are high and those providing trauma care must reevaluate the costs to determine whether the current system is feasible. This research provides justification for examining alternative methods of funding.

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